Director of Central Intelligence

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National Intelligence Estimate

Trends in Western Advanced Technology

Key Judgments

~~Secret~~

NIE 1-3/5-86W
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The Central Intelligence Agency, the Defense Intelligence Agency, the National Security Agency, and the intelligence organizations of the Departments of State, Energy, Treasury, and Commerce.

Also Participating:

The Assistant Chief of Staff for Intelligence, Department of the Army

The Director of Naval Intelligence, Department of the Navy

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TRENDS IN WESTERN ADVANCED TECHNOLOGY

KEY JUDGMENTS

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is being published separately
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SCOPE NOTE

This Estimate—the first by the Intelligence Community to analyze Western [1] technologies—assesses status and trends in nine high-technology areas. Assessments of current technology levels are, for the most part, based on demonstrated product performance and manufacturability as well as research achievements. Estimates of future technology levels are based on current technology status, research and development activities, and national technology resources and policy. Data on current and future market size are based on private-sector forecasts and other open source material and are not to be interpreted as intelligence assessments. Market shares and trade flows are considered where appropriate, but are not used as measures of technology capability. This Estimate concentrates on technology, which is a major component of competitiveness. Detailed assessments of the competitive implications of foreign advances in the nine technology areas are beyond the scope of this Estimate and could be the subject of a separate study. Firm conclusions on this subject would require a much more comprehensive treatment of factors other than technology that influence competitiveness. [redacted] 25X1

Foreign technology levels in this Estimate are assessed with respect to levels in the United States. Overall assessments of European technology levels are based on the leading country in Europe rather than an average over all European countries. Technology capabilities of the newly industrializing countries (NICs), although potentially important in determining market share, will continue to be highly dependent on access to developments in the developed countries. Our ability to assess and forecast foreign advanced technology levels is limited by gaps in our information and analytic uncertainties. The Intelligence Community has concentrated its resources on a few key technologies and on those countries developing significant technological and competitive strength. Forecasts of national differences in technology levels are greatly complicated by uncertainties in the impact of government support measures and the amount of international technology diffusion. [redacted] 25X1

[1] For purposes of this Estimate, *Western* refers to the United States, Canada, Western Europe, and Japan. [redacted] 25X1

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KEY JUDGMENTS

Overall Trends

The United States has an overall lead or is near parity in the nine technologies assessed in this Estimate,[2] but the relative US technology position has declined significantly over the past 10 years. Moreover, there are many important technology areas in which other countries already have or could attain leadership (see table). The US position is strongest in systems-oriented technologies such as aerospace, computers, and telecommunications and weakest in advanced materials, semicon-

Selected Foreign Technology Leads

	Current Lead	Potential Lead
Japan	Semiconductor materials	Josephson junction devices
	Semiconductor memory devices	Specialized semiconductor production equipment
	Semiconductor test and packaging	Optical fiber systems
	Semiconductor lasers	Erasable optical storage
	Gallium arsenide semiconductor devices	Mobile radio
	Satellite Earth stations	Robot sensors
	Machine tool controls and structure	Light water reactors
	Robot assembly	Liquid metal fast breeder reactors
	Robot manipulators, materials	
	Facsimile transmission	
	Microwave communications	
	Automotive engine ceramic parts	
	Optical storage	
	Impact printers	
	Fermentation technology	
Western Europe	Flow forming machines	Machine tools
	Sensors for machine tools	Mobile radio
	Optical storage	Light water reactors
	Videotext	Ultrasafe reactors
	Data communications switches	Magnetic confinement fusion
	Local telephone switches	
	Reinforced plastics	
	Carbon-carbon composite materials	
	Cold forging of steel	
	Hot isostatic presses	
	Liquid metal fast breeder reactors	
	Chemical isotope separation	
	Heavy water reactors	
	Nuclear fuel reprocessing	

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[2] The nine technologies are semiconductors, data processing, telecommunications, advanced structural materials, machine tools/robotics, aircraft, space, nuclear, and biotechnology. [redacted] 25X1

[redacted] 25X1

ductor components, and manufacturing technologies. The most impressive and consistent technology gains have been made by the Japanese while European technology developments have been more uneven. [redacted] 25X1

The Japanese have been very effective in translating their technology capability into manufacturable products. They have concentrated their efforts on and excel in product development, quality control, and manufacturing technologies. They are weakest in basic research and in systems design and integration, but the characterization of Japan as lacking innovation skills is not the case in several specific technology areas:

— For example, the focusing by Japanese industry and government of their technical resources on areas such as biochemical engineering, optoelectronics, robotics, advanced materials, and semiconductors has resulted in innovative developments. The Japanese R&D effort in these areas could match or exceed total US efforts, and much of the Japanese research work is coordinated and shared.

— The Japanese will very likely continue their technology gains but at a less rapid rate as they reach parity and strive for leadership. Catching up along known technical paths is much easier than true innovation, which is much more dependent on domestic R&D skills. Systems integration (including software) for computers, telecommunications, and aerospace is an area in which the Japanese will have to improve their domestic capability. Japanese engineers are very skillfull in solving isolated technical problems, but their solutions frequently are based on approaches that may be less effective when integrated into an overall system.

— Although they may experience some setbacks, Japan is likely to continue to be extremely effective in getting the maximum competitive advantage out of its technologies. In most cases in which high levels of systems integration skills are not needed and product development is evolutionary, the Japanese are likely to have sufficient technology to be the strongest competitor. Their advantages in manufacturing, quality control, corporate strategy and structure, market access, and government support can overcome all but very substantial technological deficiencies. [redacted] 25X1

Although *Europe* remains behind the United States and has fallen behind Japan in some areas, there are several important areas of European technical excellence. Europe has a first-rate *research* establishment and is successful in many areas including aerospace, nuclear

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energy, advanced structural materials, machine tools, and flexible manufacturing. Moreover, we believe European basic research and systems integration capabilities are generally superior to those of the Japanese and comparable with those of the United States in many areas:

— Europe, however, has generally been much less successful than the United States and Japan in converting research results into product and market successes. The most important problems have been a poor innovation environment, conservative corporate R&D policies, varying standards, and lack of a large domestic market.

— Europe faces a difficult technology challenge in the electronics sector. Although some technical strengths exist, Europe is not matching the breadth of Japanese and US technology achievements. Europe has emphasized only a small range of electronics technologies for narrow applications rather than committing the technical resources to develop core technologies such as semiconductors and computers and, as a result, is becoming increasingly dependent on US and Japanese technology in these areas.

— R&D programs and other steps are being taken to reduce dependencies in these areas and improvements are possible; they will, however, probably be inadequate given the strength and momentum of the United States and Japan. [redacted] 25X1

Factors Influencing Technology Levels

International technology diffusion will continue to be extremely important in determining future technology levels:

— Although all countries potentially can benefit from acquisition of foreign technology, based on past performance, the Japanese will very likely benefit the most from this process. They will continue to acquire foreign technology through a wide range of mechanisms while, at the same time, protecting their own technology. Although Japanese technology levels are very high, there will continue to be a need for access to foreign technology. The Japanese are aware of this and will put a high priority on keeping technology acquisition channels open.

— The Europeans will also benefit from technology acquisition, but, in sectors such as electronics in which they fail to develop indigenous R&D capabilities, they will continue to lag the leaders. In other areas such as aerospace, nuclear energy, and advanced materials, the Europeans will gain from foreign technology if they continue to match acquisitions with parallel R&D efforts. [redacted] 25X1

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One of the most important and least predictable factors influencing comparative technology levels will be the *increased importance of international corporate strategic alliances*. Such cooperative ventures have long been crucial in nuclear and aerospace technologies, but their importance is now being extended to other areas such as semiconductors, data processing, and telecommunications. Even the strongest companies will probably be driven to form alliances to gain access to markets, share development costs, and preempt competitors from forming effective combinations.

— *The United States* is well positioned to take advantage of this trend, having the largest markets and many of the most attractive potential partners. Those companies that are the most effective in forming and managing international cooperative ventures will have a great competitive advantage. The increased use of such ventures will lead to greater technology flows and, depending on the skills and objectives of the participants, could result in a decline in technology gaps. 25X1

Government science and technology policies will continue to contribute significantly to technology levels. The United States, Japan, and most European countries are likely to continue to support technology development programs and policies. The extent to which governments are willing to underwrite the R&D process and to reduce the associated financial and technical risks can influence the state of international competition in certain advanced technologies. There are major government-sponsored R&D programs in each of the nine technology areas covered in this Estimate. Not all technology enhancement programs will be successful and those that succeed in developing technology may fail to produce an effective competitor. Japan's technology development programs will very likely yield the most effective results, primarily because their programs are well focused, consistent, and make use of a wide variety of support measures. 25X1

Economic Implications

Increased foreign technology capability can have significant effects on US economic interests. Positive effects include the availability of better or lower cost products, opportunities for international technology cooperation, and stimulation of increased US R&D activity. Negative effects include adverse impacts on US balance of trade, employment patterns, industrial structure, and industrial capability. In areas of potential foreign technical superiority, such as semiconductors and advanced materials, the United States could be increasingly at a dis-

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advantage. In other areas such as civil aircraft, machine tools, and computers, foreign technology capabilities are likely to be sufficient to enable them to compete effectively in several markets, formerly dominated by US firms. [redacted] 25X1

The world market (non-Communist) for direct sales in the technology sectors assessed in this Estimate is currently about $400 billion annually and will probably exceed $1 trillion annually by the mid-1990s. Indirect impacts on other sectors will be much larger:

— Although technology leadership is not necessary for market leadership, market success can result in eventual technology leadership, as competitors are forced to cut back on R&D. Some firms may "target" certain overseas markets, adopting a strategy of sacrificing profit margins in hopes of gaining market share over time; firms in targeted markets that are unable or unwilling to forgo current income in response may be forced to withdraw or be absorbed.

— For example, we believe that the early Japanese market success in high-volume semiconductor memory devices was not based on technological advantages. Nevertheless, Japan had sufficient technology to dominate the market and force a major restructuring of the US and European merchant semiconductor industry. As a result of US and European cutbacks in investment, Japan has now attained a clear lead in memory technology. [redacted] 25X1

Military Implications

Because most of the high technologies considered in this Estimate are dual use—having civil and military applications—there are important implications for military capabilities as well as economic interests. *Increased foreign technology capability has three major military dimensions affecting US interests:*

— *Use of foreign technology for US military applications.* A mix of factors is contributing to the potential for increased US military use of technology produced by allies:

- In some cases, US industry, skeptical about market opportunities, is not matching current foreign investment and R&D.
- At the same time, foreign firms are pursuing longer term R&D and investment strategies targeting niche markets to develop capabilities that can be extended to broader markets. Foreign sources are already being used for some advanced materials, optical components, advanced semiconductor technologies, and production equipment for US military programs.

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- Failure to establish or retain indigenous capabilities in leading-edge technical areas could result in future sizable US technology lags.

- These lags need not become serious vulnerabilities. If managed effectively, foreign technical excellence can provide opportunities for reduced costs or for joint development and technology exchanges. In cases in which this is unsatisfactory, independent US capabilities can be developed. In such situations, development costs could be reduced if the United States has sufficient information about which foreign R&D paths have been successful.

— *Increase in independent foreign military capability, including export potential:*

- The French, the West Germans, and the Japanese are all considering the development of independent space-based intelligence collection systems even though their overall capabilities in key electronics, optics, and systems technologies are behind US levels. European arms exports are supported by excellence in aerospace technology, such as British engines and French avionics.

- Japanese excellence in dual-use technologies is also significantly increasing Japanese military technology potential. This potential can support increased domestic independence in military systems and provide the basis for an arms export sector, although Japanese politics probably will preclude such exports for a long time.

— *Widening of technology gap with Soviet Union, if know-how can be protected.* Increased Western technology competition will also have substantial impact on the Soviet Union. Although quantification is impossible, it is almost certain that world technology levels are increasing at a very fast rate as a result of the intense commercial competition among Western countries. Increased Western capabilities, however, do provide alternate sources of high technology, and US loss of technology leadership can in some cases complicate efforts to restrict transfers. To whatever extent transfer of this Western technology can be prevented, the lag in Soviet civil and military technology levels is likely to increase. [redacted] 25X1

Note: *The Director, Bureau of Intelligence and Research, generally concurs in the analysis of specific technologies in the text of this Estimate and commends this effort as a most important analytical challenge. However, in his view, the evolution of, and the prospects for, each technology in a particular country are so distinct that generalizations regarding relative national levels and capacities, such as those attempted in the Key Judgments, are not meaningful. Moreover, in his view, the relationship between technology and competitiveness, involves complex political, economic and social considerations, which are not dealt with in this Estimate in sufficient depth to support the judgments on industrial and military implications. In addition, he does not agree with what appear to be some of the assumptions underlying these judgments—such as the assumption that there is an intrinsic loss to the US in a growing capacity in industrial/military technology among the allies.* [redacted] 25X1

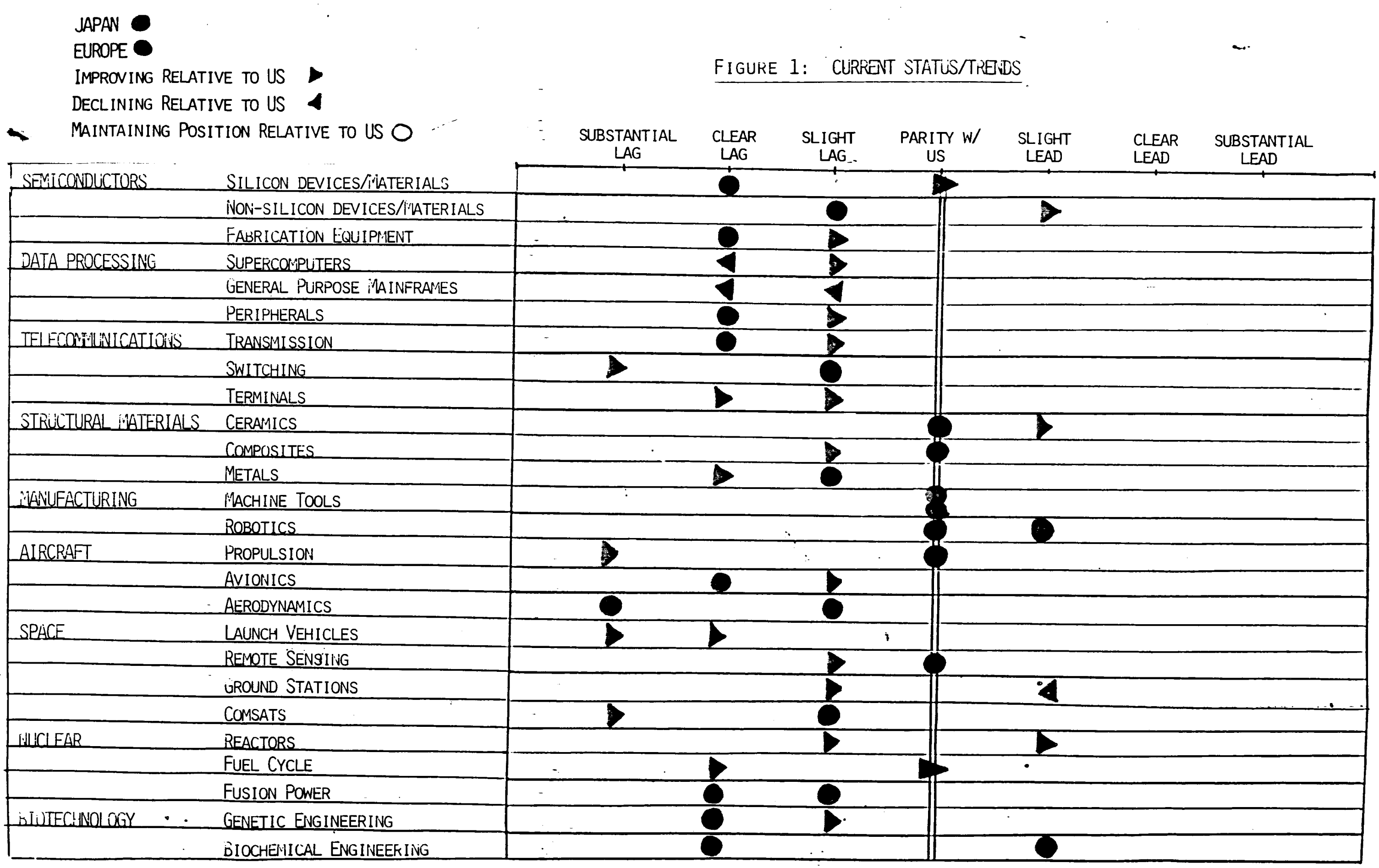

FIGURE 1: CURRENT STATUS/TRENDS

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